

April 7, 2004

TO: S. Waldherr

FROM: A. Andujo / E. Hampton / S. Guduru

SUBJECT: WMAP Loading Study

REFERENCE: Email from Stefan Waldherr dated 03/23/04.

This study is in response to a three-part study request message received from Stefan Waldherr. The purpose of this study is to evaluate the DSN's ability to support several scenarios in which WMAP requirements are modified, including alternate subnets.

Analysis was accomplished using the FASTER (Forecasting and Scheduling Tool for Earth-based Resources) forecasting system, TIGRAS (TMOD Integrated Ground Resource Allocation System) scheduling tool and the updated mission set database from the February 2004 Resource Allocation Review Board (RARB). Only antenna time conflicts were considered, not MCD-3 conflicts.

Overall Results

The requirements and trajectory of the WMAP mission allow the spacecraft to be supported with minimal impact to DSN resources. As this study shows, even with a 200% to 400% increase in the mission's support hours the DSN is still able to provide the mission with very nearly 100% supportable time. This is due largely to the spacecraft's trajectory which places the spacecraft in a relatively quiet part of space, an anti-Sun orbit and to the minimal requirements sought by the project. Although most missions will eventually overlap with WMAP's viewperiod, WMAP's requirements of 45 minutes to 4 hours per day allow it to attain its support with little or no impact to other missions and DSN maintenance. According to this study WMAP can expect to maintain requirement even under the heaviest contention periods such as when multiple downtimes occur or during high activity periods.

In all the scenarios discussed in this study WMAP made little or in most cases no impact to other missions. The maximum decrease in supportability seen was approximately 2%. In no scenario discussed was any other mission or activity detrimentally affected.

Recommendations

It is our recommendation that the WMAP mission continue to use the 70 meter subnet as long as possible, specifically DSS-63 as well as increase DSS-43 usage, at least through January 2005 when DSS-14 returns to service. We also recommend that the project consider using DSS-54 or 66 for Uplink concurrently with DSS-63 Downlink. Schedulers are now preparing schedules up to week 45 of 2004 a change in requirements later would ease the transition to new requirements.

We also recommend that the DSN keep DSS-63 operational until DSS-14 returns to service in January 2005.

Part 1 - Introduction

The purpose of this study is to evaluate if WMAP requirements [for the mid-range allocation (current to December 2004)] can be supported as requested:

1. Alternate WMAP support scenarios for the for the mid-range allocation (Current to December 2004)
 - a. Can WMAP support requirements be met on just DSS-14 and DSS-43 (45 minutes excluding setup and teardown)
 - b. Can WMAP requirements be met if WMAP supports move from the 70M to the 34-meter beam waveguide one(34B1) (2-hour tracks excluding setup and teardown)

Summary of Results

The following analysis of part 1 implies, that using the S-band High Power Transmitter at DSS-63 until at least DSS-14 is operational in mid December 2004. If the transmitter fails, DSS-54, 66 should be used for uplink or the supports should be moved to DSS-43. In addition, 34B1 can provide the adequate backup for WMAP in the non-negotiated weeks 44-53 of 2004.

Part 1a

Can WMAP support requirements be met on just DSS-14 and DSS-43 (45 minutes excluding Setup and teardown)?

Assumptions

- Due to DSS-14 downtime for antenna controller and hydrostatic bearing replacement in weeks 28 thru 50. WMAP requirements during these weeks move to DSS-43.
- When WMAP supports are moved from 70M to 34B1 subnet, routine supports are changed from 45minutes to 2-hour duration, whereas the duration of maneuver supports remain unchanged.
- Setup and teardown time on 70M is 75 minutes and 15 minutes respectively.
- Setup and teardown time on 34B1 is 1-hour and 15 minutes respectively.
- Negotiated schedules are available through week 43.
- The current supportable time on a subnet is the supportable time (in %) on the subnet after updating the mission set database with the February 2004 RARB approved recommendations.

Assessment on 70M subnet:

Figure 1 illustrates the current supportable time on the 70M subnet along with the supportable time on 70M subnet when:

1. WMAP requirements are on DSS-14, 43
2. WMAP requirements are entirely on DSS-43

Forecast shows no difficulties in moving support to either DSS-14 or DSS-43 immediately. Upon analyzing the negotiated schedule from weeks 14 thru 27 when WMAP can use both DSS-14 and DSS-43, forecast shows no difficulties in attaining full support. The supports scheduled during this period are:

1. 48 supports are scheduled on DSS-14
2. 41 supports are scheduled on DSS-43
3. 9 supports are scheduled on DSS-63

3 of the nine supports scheduled at DSS-63 can move to DSS-14 and DSS-43 immediately. Moving the remaining 6 supports to DSS-14 and DSS-43 would impact GBRA (Ground Based Radio Astronomy) and VGR2 (Voyager 2).

The supports scheduled during the period from week 28-43 (when DSS-14 is down) are:

1. 40 supports are scheduled on DSS-43
2. 72 supports are scheduled on DSS-63

Analysis shows that 8 supports can be moved to DSS-43 immediately. Moving the remaining supports to DSS-43 will primarily impact VGR2 and GBRA. To minimize disruption of negotiated schedules the project scheduler should determine if either DSS-54 or DSS-66 could provide uplink support and continue to use DSS-63 for downlink support.

During the remainder of the scheduled DSS-14 downtime period, weeks 44 thru 50, an attempt should be made to schedule more use of DSS-43.

Part 1b

Can WMAP requirements be met if WMAP supports move from the 70M to the 34-meter beam waveguide one (34B1) (2-hour tracks excluding setup and teardown)?

Assessment on 34B1 subnet:

Forecast shows that WMAP is nearly 90% supportable when moving WMAP supports to the 34B1 subnet, and increase pass duration to 2-hours (double duration of 70M) for routine supports.

Figure 2 illustrates the current supportable time on the 34B1 subnet, along with the supportable time on 34B1 subnet when all WMAP requirements are on 34B1.

Based on analysis of the negotiated schedules for weeks 14 thru 43 it has been determined that moving WMAP to 34B1 would primarily impact DSS maintenance, Ulysses, Genesis and VGR2, and in the remaining weeks (44 thru 53) of 2004, moving WMAP requirements to the 34B1 subnet would allow nearly 90% supportability.

Figure 1

**Comparison of Supportable Time (in%) on 70M Subnet
With Current Load on 70M Vs
Loading on 70M With All WMAP Requirements On Different 70M Antenna Combinations.**

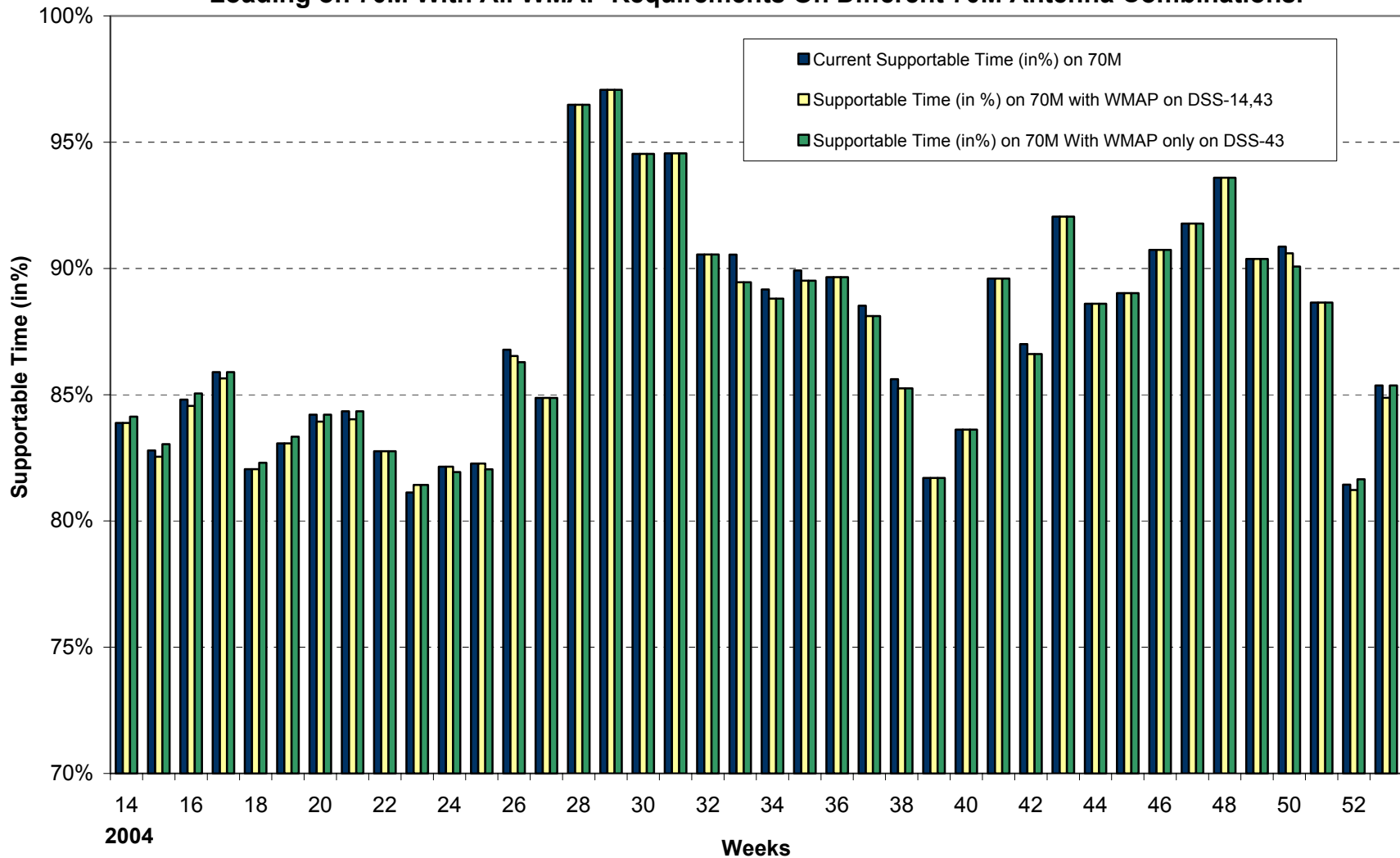
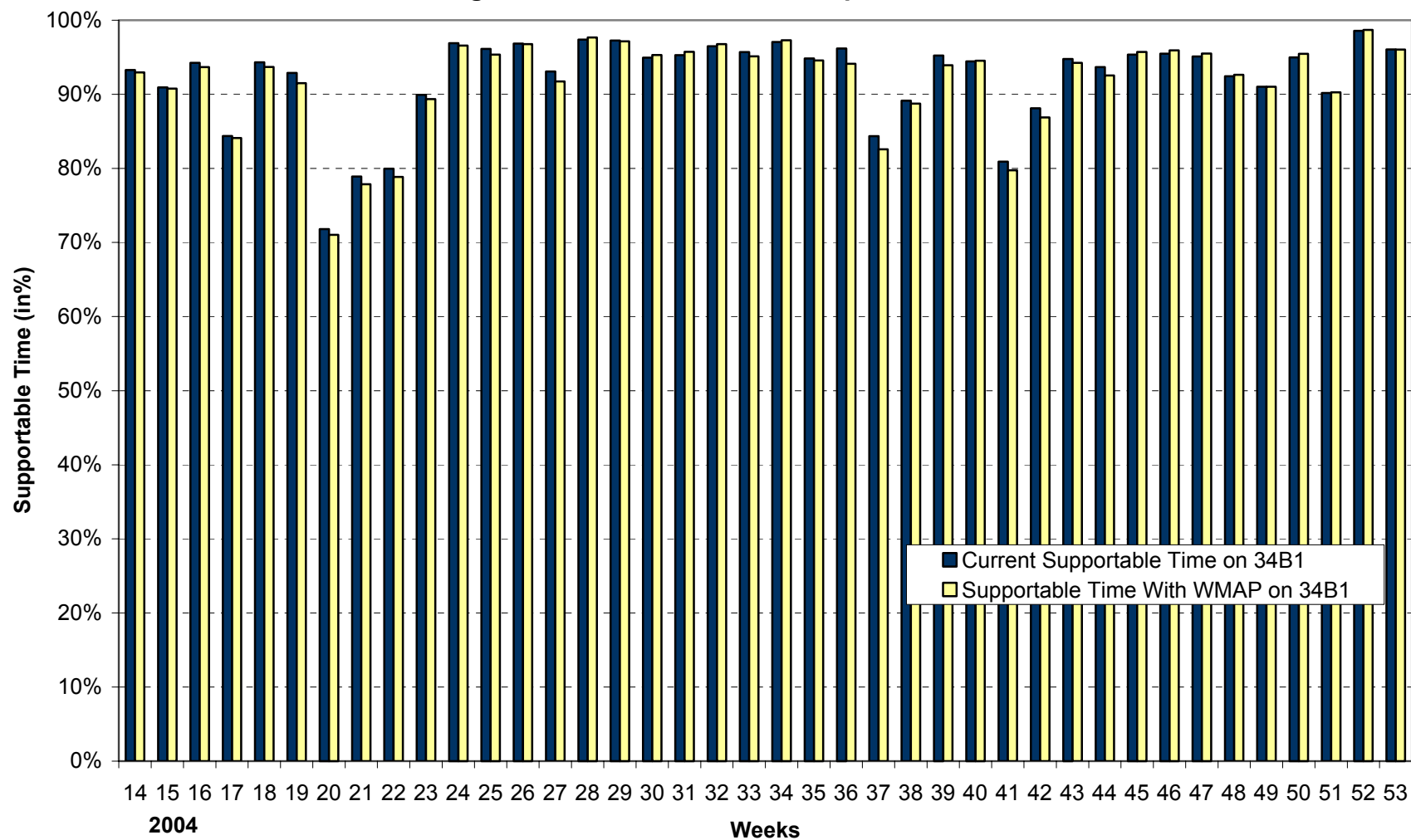


Figure 2

**Comparison of Supportable Time (in%) on 34B1
With Current Load on 34B1 Vs
Loading on 34B1 With All WMAP Requirements On 34B1**



Part 2 - Introduction

The purpose of this study is to evaluate if WMAP requirements [for the mid-range allocation (current to December 2004)] can be supported as requested:

1. Alternate WMAP support scenarios for the Long Range 2005-2007.
 - a. Can WMAP requirements be met if WMAP supports move from the 70M to the 34-meter beam waveguide one(34B1) (2-hour tracks excluding Setup and teardown/post cal)

Summary of Results

On average, the current supportable time on 70M is 88%. By moving the WMAP requirements to DSS-14 and DSS-43, the supportable time decreases by 1%.

WMAP requirements are currently nearly 100% supportable. In moving WMAP requirements to:

1. DSS-14,43 they are 98% supportable
2. DSS-14 (in weeks 14-27 and weeks 51-53) and to DSS-43 (in weeks 28-50), they are 97% supportable
3. DSS-43, they are 99% supportable.

The current average supportable time on 34B1 is 92%. The average supportable time on the subnet remains unchanged by moving all WMAP requirements to 34B1.

The current WMAP requirement of 5-hours in week 23 on 34B1 is 100% supportable. By moving all WMAP requirements to 34B1, it changes to 92% supportable.

Assumptions

- DSS-14 is down for antenna controller and hydrostatic bearing maintenance in weeks 28 thru 50. Only DSS-43 is used to support WMAP requirements during these weeks.
- Maneuver supports are not doubled whereas routine tracks are doubled to 2-hours on 34B1.
- Setup and teardown time is 75 minutes and 15 minutes respectively for 70M.
- Setup and teardown time is 1-hour and 15 minutes respectively for 34B1.
- The current supportable time on a subnet is the supportable time (in %) on the subnet after updating the mission set database with the February 2004 RARB approved recommendations.

Assessment of 70M subnet:

Figure 1 illustrates the current supportable time on the 70M subnet, against supportable time on 70M when:

3. WMAP requirements are on DSS-14, 43
4. WMAP requirements are on DSS-14 (in weeks 14-27, 51-53) and on DSS-43(in weeks 28-50)
5. WMAP requirements are entirely on DSS-43.

With WMAP on DSS-14, 43

Figure 2 illustrates the current supportable time on the 70M along with the supportable time on 70M when WMAP requirements are on DSS-14 and 43.

In comparing the current supportable time on the 70M subnet with the supportable time with all WMAP requirements on DSS-14 and DSS-43, it is found that the supportable time remains the same in most weeks (14,18,19,22,24,25,27-32,36,39-40, 41-49 and 51). The supportable time falls slightly by 1% in the remaining weeks, except in week 33 where it falls by 2% and in week 23 when it increases by 1%.

With WMAP on DSS-14

Figure 3 illustrates the current supportable time on the 70M subnet and with the supportable time on 70M when WMAP requirements are on DSS-14.

In comparing the current supportable time in weeks 14 thru 27, an increase of 1%, except in week 16 and 23-25 when it decreases by 1%. In the remaining weeks when DSS-43 is used instead of DSS-14, the supportable time mostly remains the same, with a slight increase or decrease (by 1%), except in weeks 33 and 50 where it falls by 2%.

With WMAP on DSS-43

Figure 4 illustrates the current supportable time on the 70M subnet along with supportable time on 70M subnet when WMAP requirements are on DSS-43.

The supportable time:

1. increases by 1% in weeks (14-19, 23 and 52-53)
2. decreases by 1% in weeks (24-26, 34-35, 37-38 and 42)
3. decreases by 2% in weeks 33 and 50
4. remains unchanged in the remainder of the weeks

This shows that the current supportable time does not change appreciably by moving the WMAP requirements from 70M to just DSS-14 and DSS-43.

Assessment on 34B1 subnet:

Figure 5 illustrates the current supportable time on the 34B1 subnet along with supportable time on 34B1 subnet when all WMAP requirements are on 34B1.

With WMAP on 34B1

The supportable time remains unchanged in most of the weeks except for an increase or decrease by 1% in a few weeks.

Figure 1

Comparison of Supportable Time (in%) on 70M Subnet With Current Load on 70M Vs

Loading on 70M With All WMAP Requirements On Different 70M Antenna Combinations.

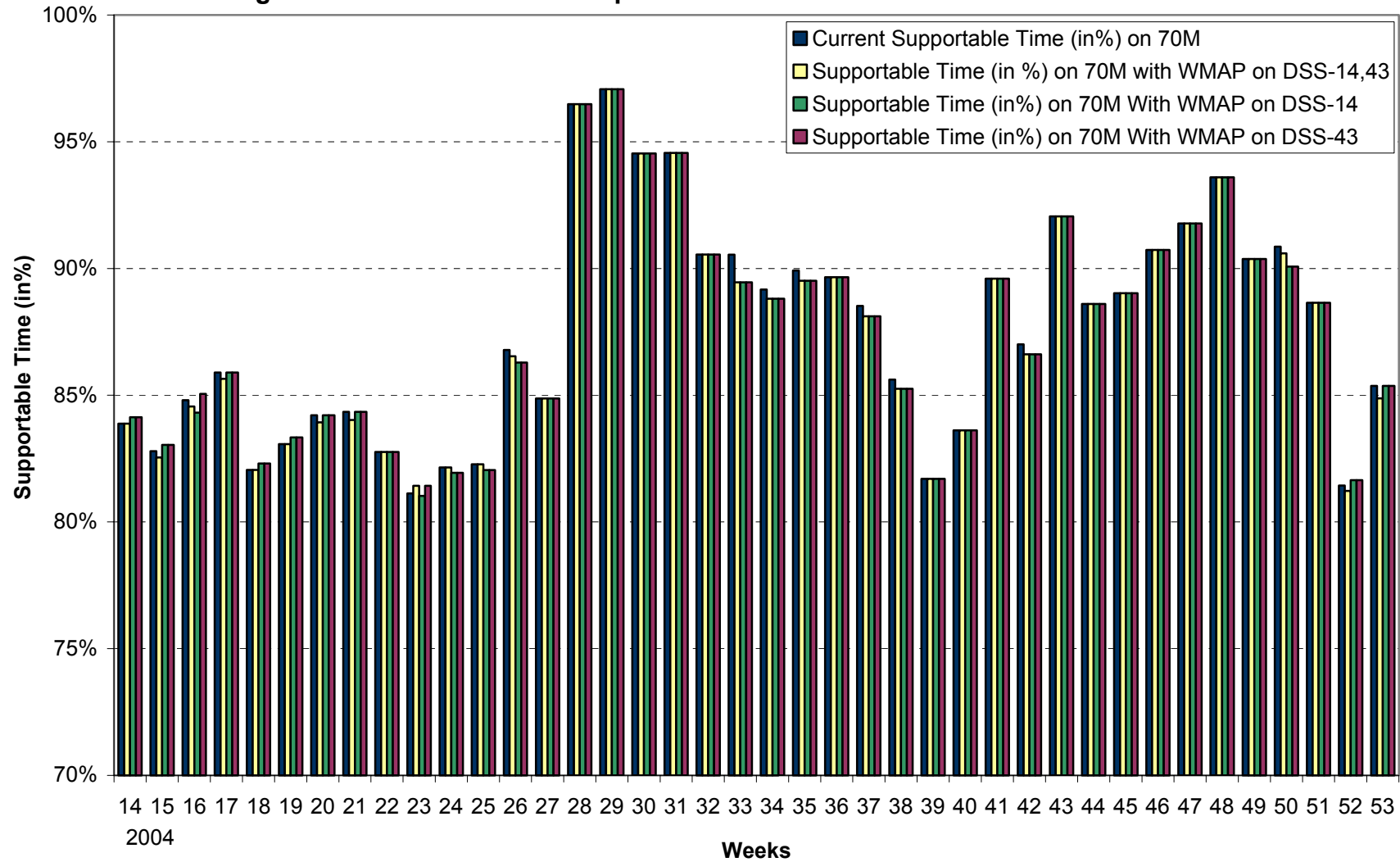


Figure 2

**Comparison of Supportable Time (in%) on 70M
With Current Load on 70M Vs
Loading on 70M With All WMAP Requirements on DSS-14,43**

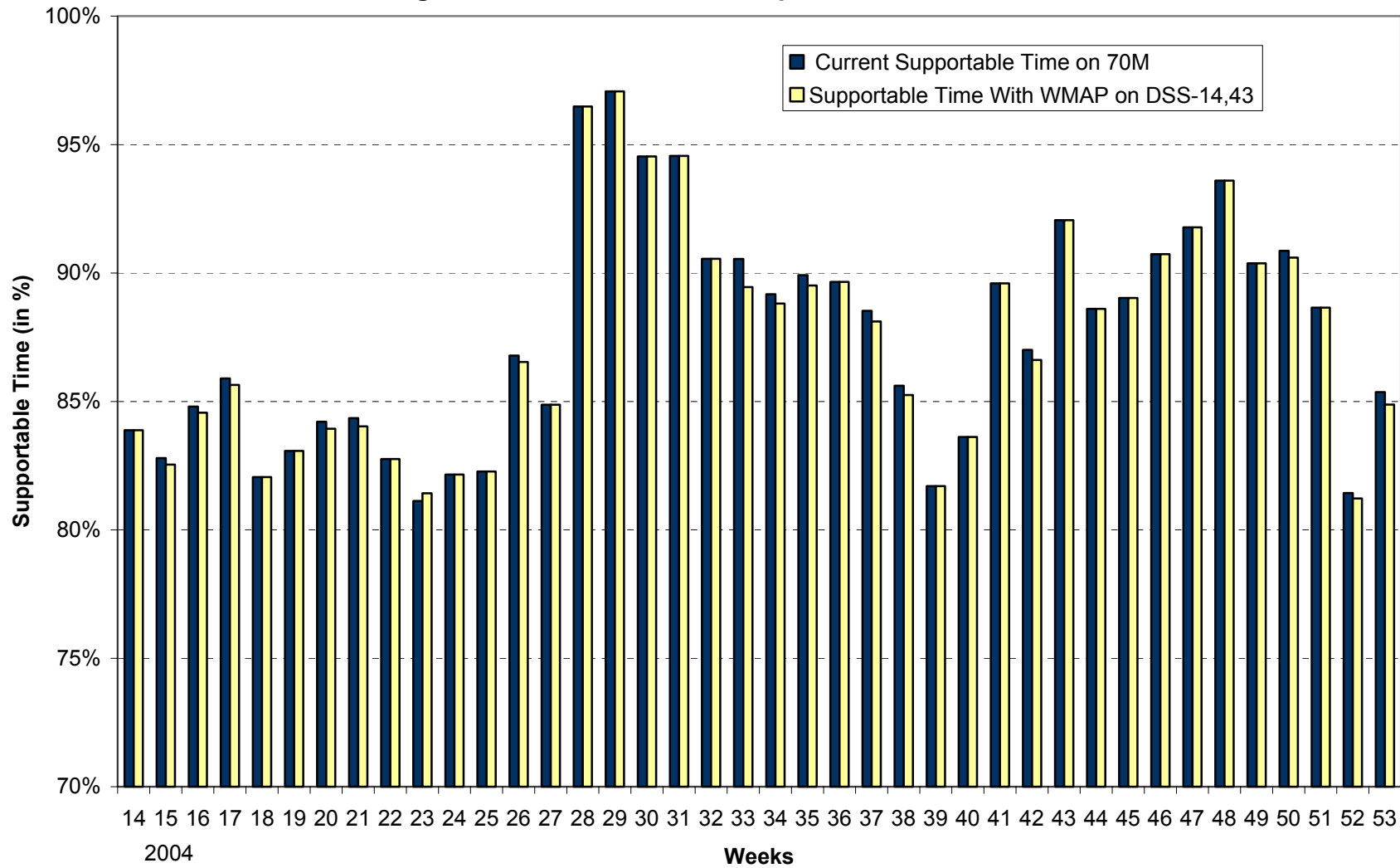


Figure 3

**Comparison of Supportable Time (in %) on 70M
With Current Load on 70M Vs
Loading on 70M With WMAP Requirements on DSS-14**

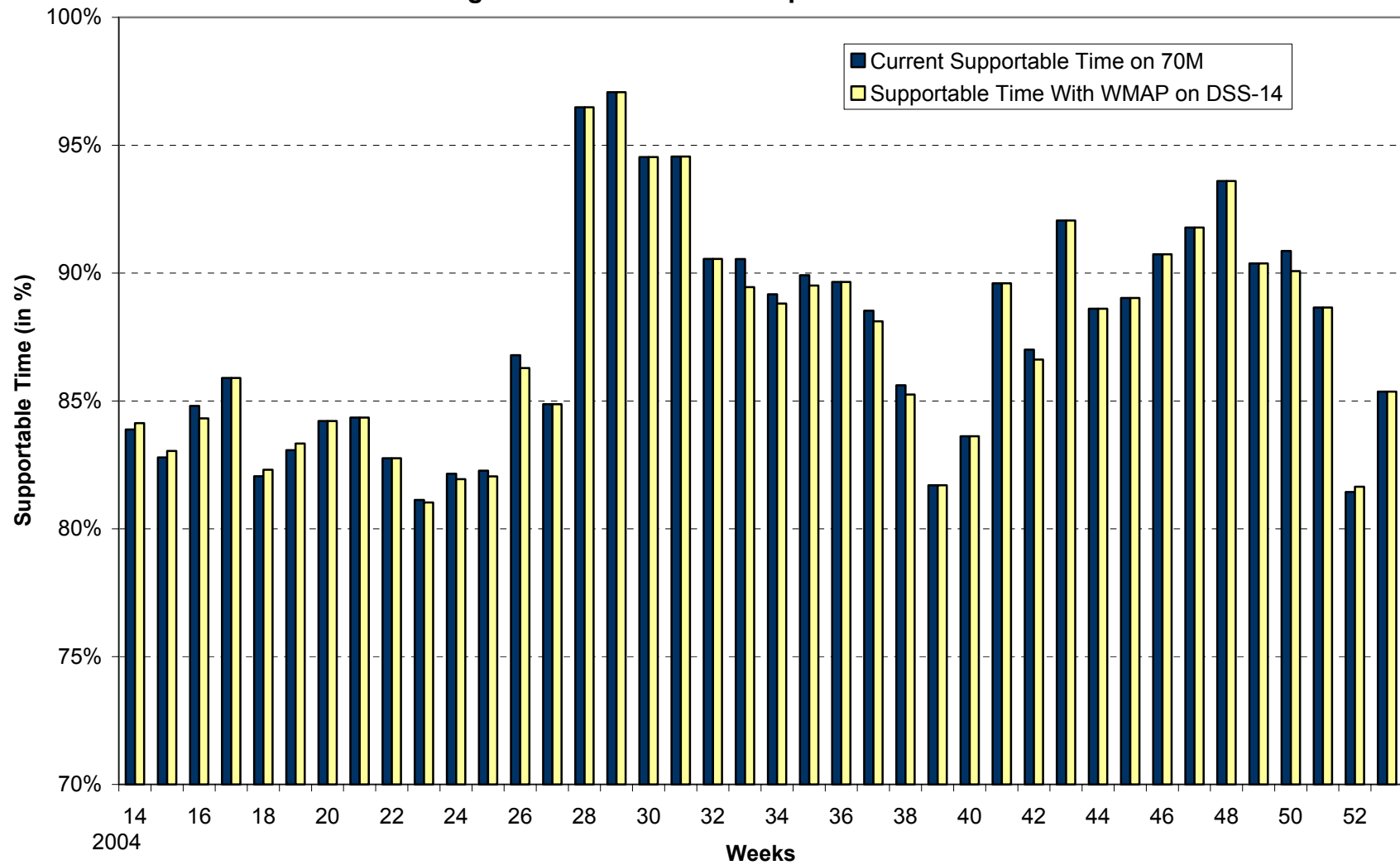


Figure 4

**Comparison of Supportable Time (in %) on 70M
With Current Load on 70M Vs
Loading on 70M With All WMAP Requirements on DSS-43**

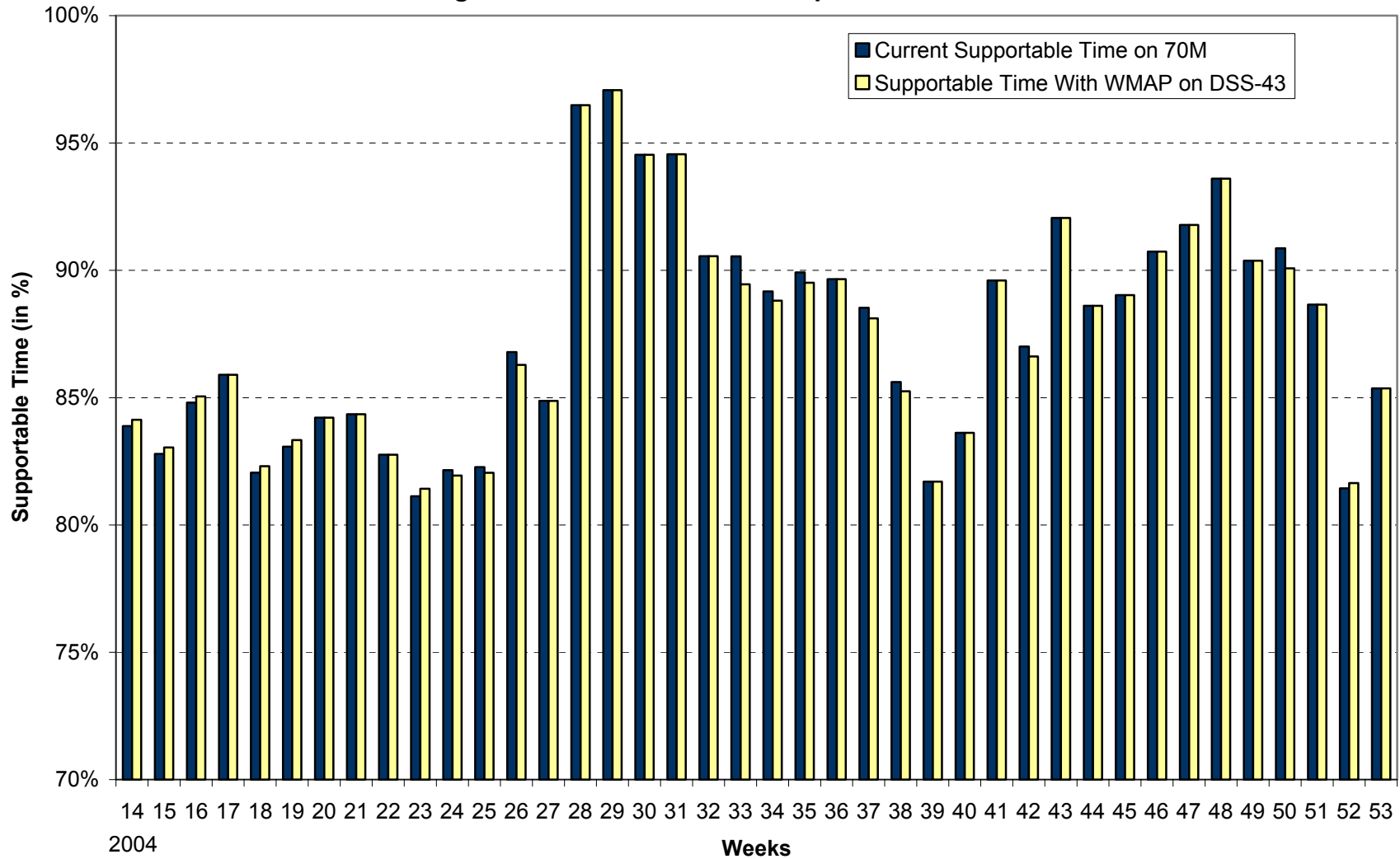
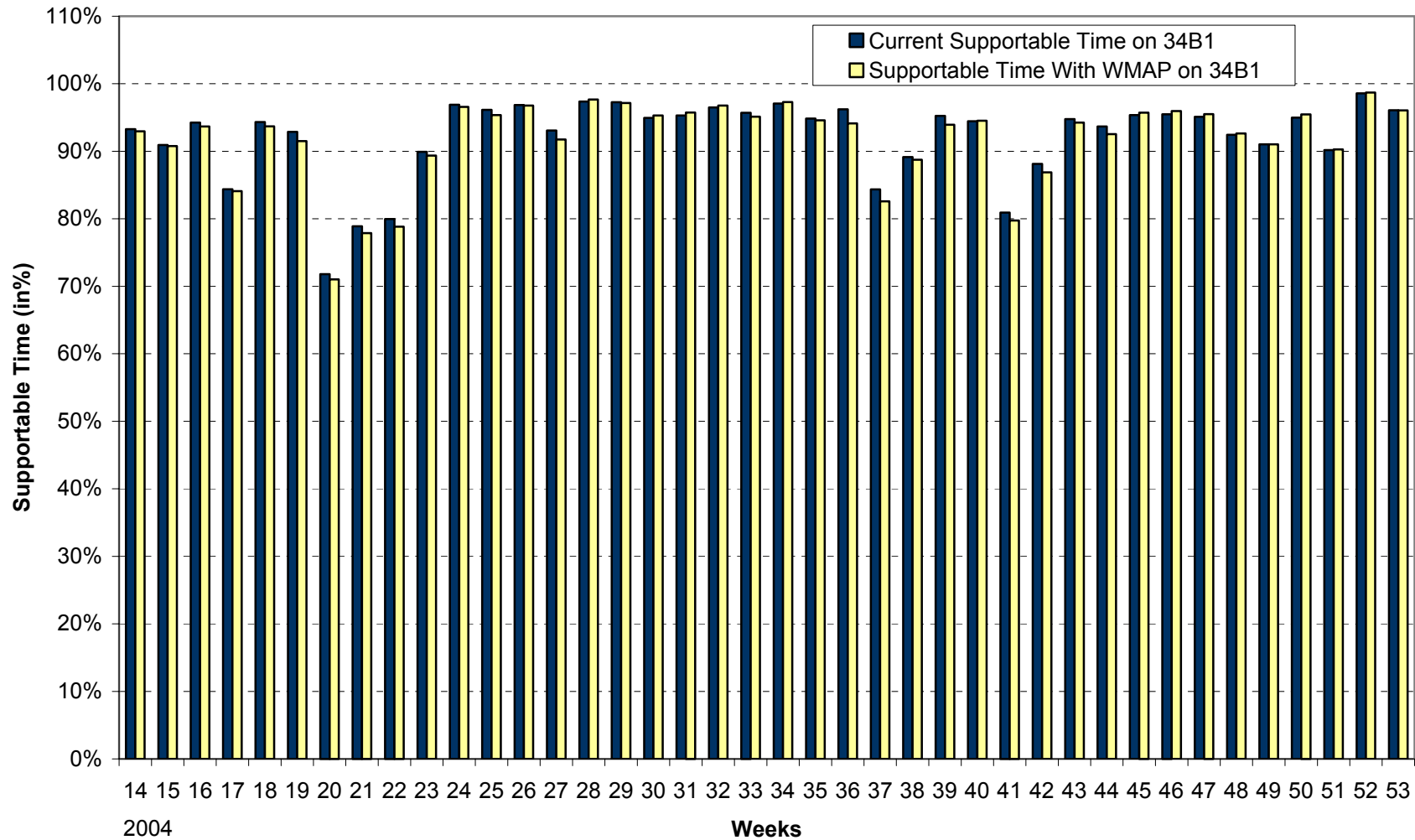


Figure 5

**Comparison of Supportable Time (in%) on 34B1
With Current Load on 34B1 Vs
Loading on 34B1 With All WMAP Requirements On 34B1**



Part 3 - Introduction

This study is in response to part three of the message received from Stefan Waldherr. The purpose of this study is to evaluate the DSN's ability to support several scenarios in which WMAP requirements are modified, including alternate subnets. Part 3 of this study focuses on the following:

1. Alternate WMAP support scenarios for the Long Range 2005-2007.
 - a. Can WMAP requirements be met if WMAP uses 70-meter for downlink only and 26-meter for uplink (45 minute tracks without setup and teardown)?
 - b. Can WMAP requirements be met if WMAP uses 34-meterHEF for downlink only and 26-meter for uplink (2 hour tracks)?

Summary of Results

Overall, the manipulation of support requirements may increase or decrease the amount of lost time at a given subnet by a small amount, but supportability is fully maintained. However it is recommended that WMAP continue to use a single antenna for uplink and downlink. This would avoid difficulty in scheduling multiple assets at the same time, which usually proves to be challenging for mid-range and DSN scheduling.

Part 3a

Can WMAP requirements be met if WMAP uses 70-meter for downlink only and 26-meter for uplink (45 minute tracks without setup and teardown)?

Assumptions

- Current support for WMAP at the 70M subnet is unchanged, including maneuvers
- 70M support has been duplicated on the 26M at 45 minutes per pass
- 70M D/L and 26M U/L tracks would be performed in a pseudo array
- A 30 minute setup and 10 minute teardown was added to 26M supports
- All 34HEF antennas have a downtime during this period. DSS-65 is down for 5 months in 2005 and in weeks 17 and 18 both DSS-15 and DSS-65 are down concurrently

Assessment of WMAP Supportability:

Changes in lost time percentages for the mission range from 0% to 1.5% on the 26M subnet throughout the entire period. The mission should be fully supportable on the 26M subnet. WMAP's anti-Sun trajectory allows WMAP to get 26M support without interfering with most other users of the subnet, which are for the most part in the Sun view.

Assessment of the 26M subnet:

Adding WMAP 26M uplink support increases lost time percentages for the 26M subnet between 0% - 0.3%, but in most cases reduces lost time percentages by up to 0.3%. This is attributed to the fact that increases to requested hours on the subnet, without an increase to lost time reduces the lost time percentage for the whole subnet.

Assessment of the 70M subnet:

In this portion of the study there are no relevant modifications to WMAP 70M support, therefore there is no change in supportable time.

Conclusions

A change in support requirements for WMAP to utilize both the 70M subnet for Downlink and 26M subnet for Uplink is fully supportable.

Part 3b

Can WMAP requirements be met if WMAP uses 34-meter HEF for downlink only and 26-meter for uplink (2 hour tracks)?

Assumptions

- Current support for WMAP at the 70M subnet is moved to the 34M HEF subnet, including Maneuver support.
- 34M HEF and 26M track time has been increased to two hours per pass.
- 34M D/L and 26M U/L tracks would be performed in a pseudo array.
- A 40-minute setup and 10-minute teardown was added to 26M supports.
- A 30-minute setup and 15-minute teardown was added to 34M HEF supports.

Assessment of WMAP Supportability:

Figures 1 and 2 illustrate supportability for WMAP at the 34H subnet is at an acceptable level; although lost time percentages are markedly increased the mission would still be able to confidently meet requirements.

Assessment of the 34M HEF subnet:

Figures 3 and 4 illustrate that moving WMAP support from the 70M subnet to the 34M HEF subnet and increasing track time to 2-hours from 45-minutes would increase lost time on the subnet, but oversubscription of the 34M HEF subnet would still be well within a manageable level.

Conclusions

A change in support requirements for WMAP to utilize both the 34M HEF and 26M subnets is fully supportable.

Figure 1

WMAP Lost Time % at 34H vs. 70M

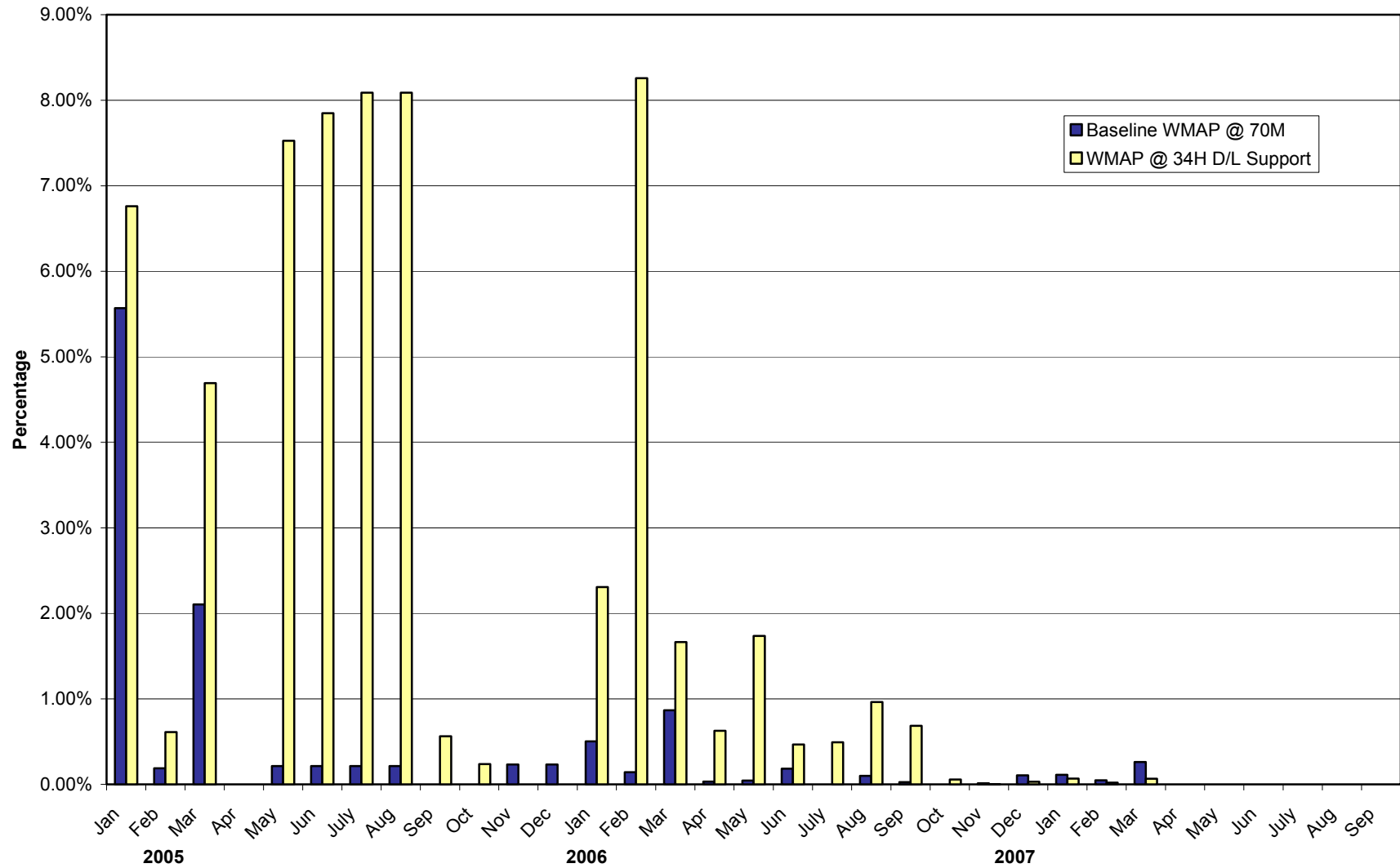


Figure 2

WMAP Lost Time in Hours at 34H vs. 70M Subnets

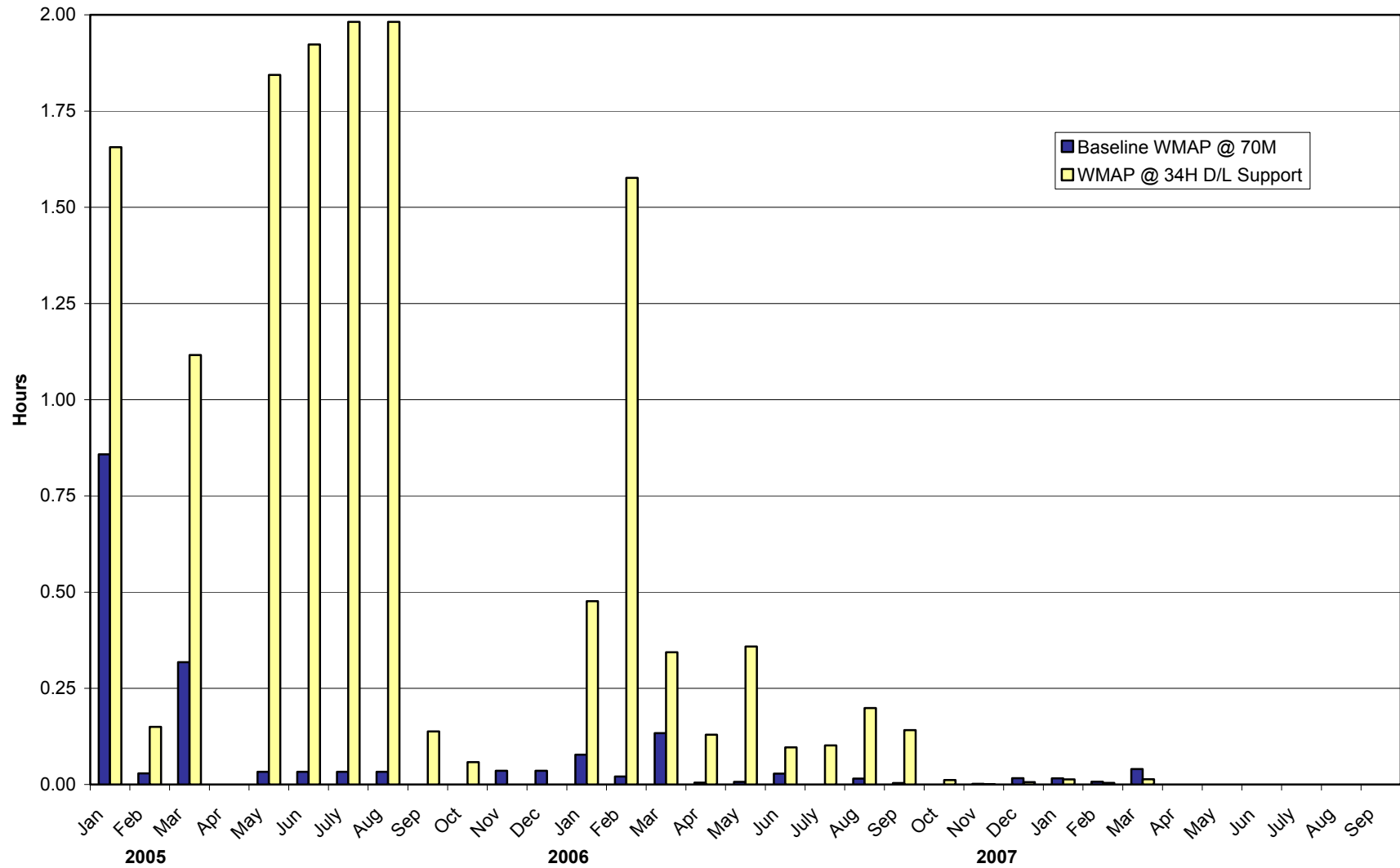


Figure 3

Change in 34H Subnet Lost Time % with WMAP

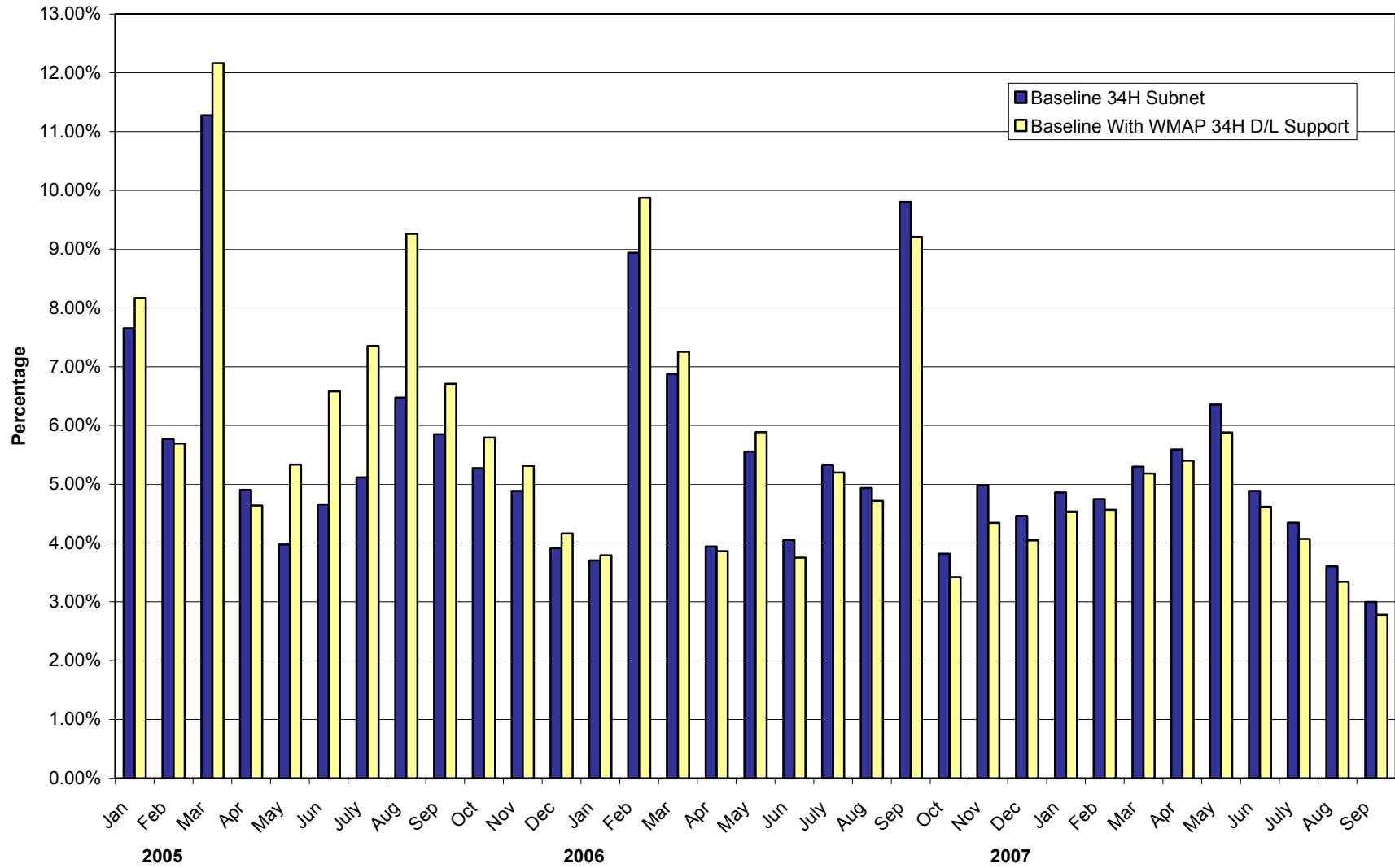
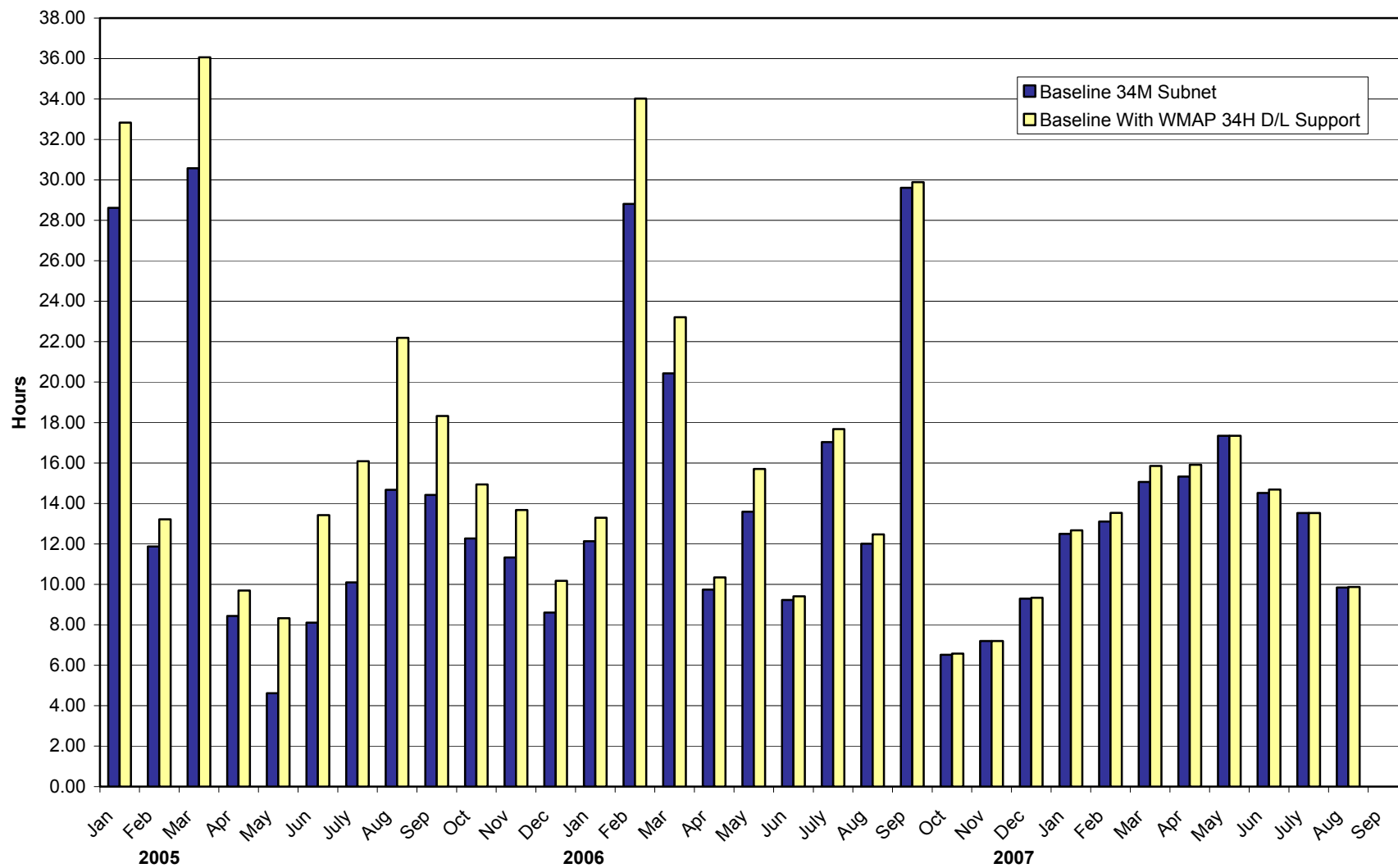


Figure 3

Change in 34H Lost Time in Hours with WMAP



As always, the results of this study are subject to change, in that network loading changes as requirements for planned missions are input and updated and periods of antenna downtime are identified. We will continue to work with WMAP and other users of the DSN to maximize the time available for each individual user.

cc:

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